Stopping the Dance in the Tevatron

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19 May 2011

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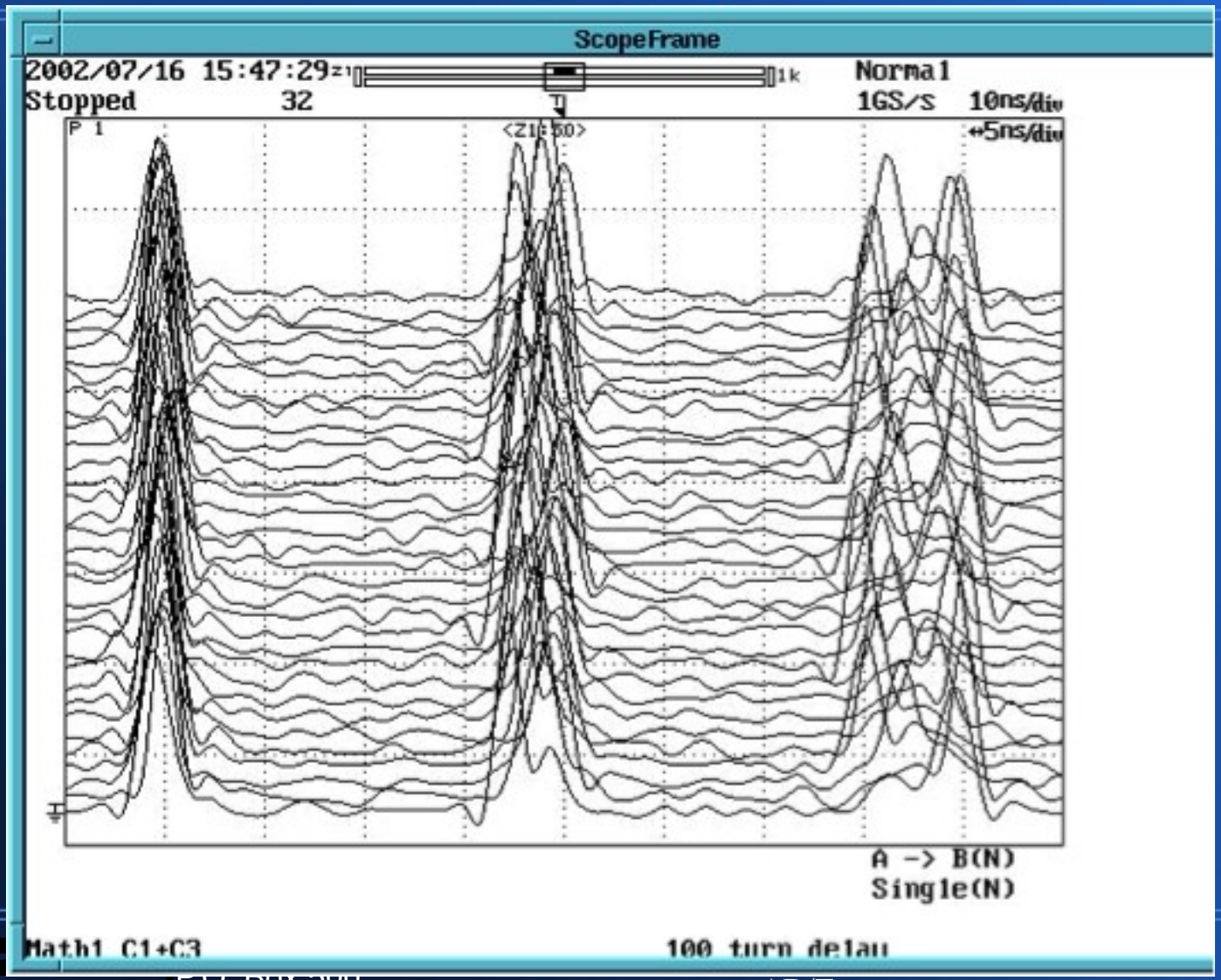
Overview

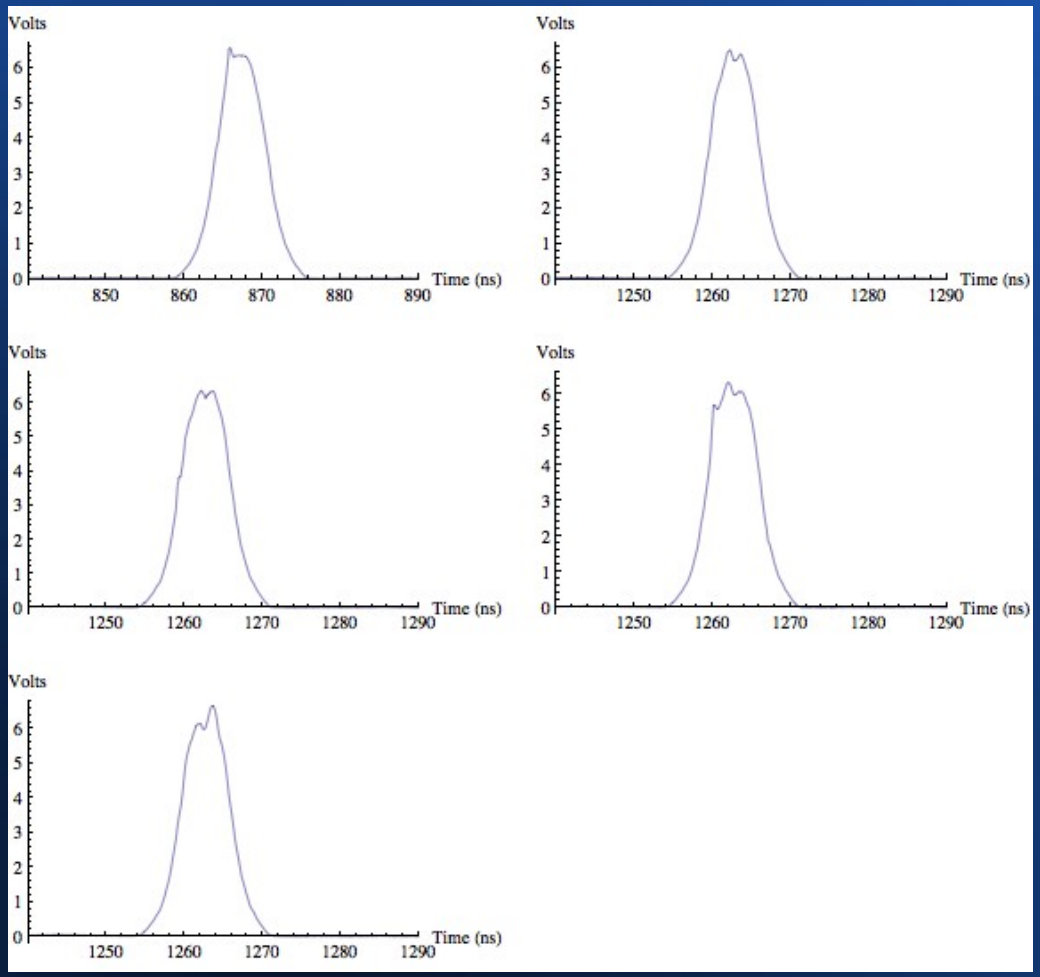
- The goal is to see whether experiments can confirm theory.
- It is well known that the Tevatron beam exhibits longitudinal oscillations which do not damp out.
- Can use the phase shifter module used for longitudinal dampers and chromaticity tracking to shake the beam.

Dancing Bunches (Uncoalesced)



- Uncoalesced beam
- 100 turns between traces
- Synchrotron freq ~87 Hz
- Dance continues indefinitely.
- Inductive impedance model explains the dance

Dancing Bunches (Coalesced)



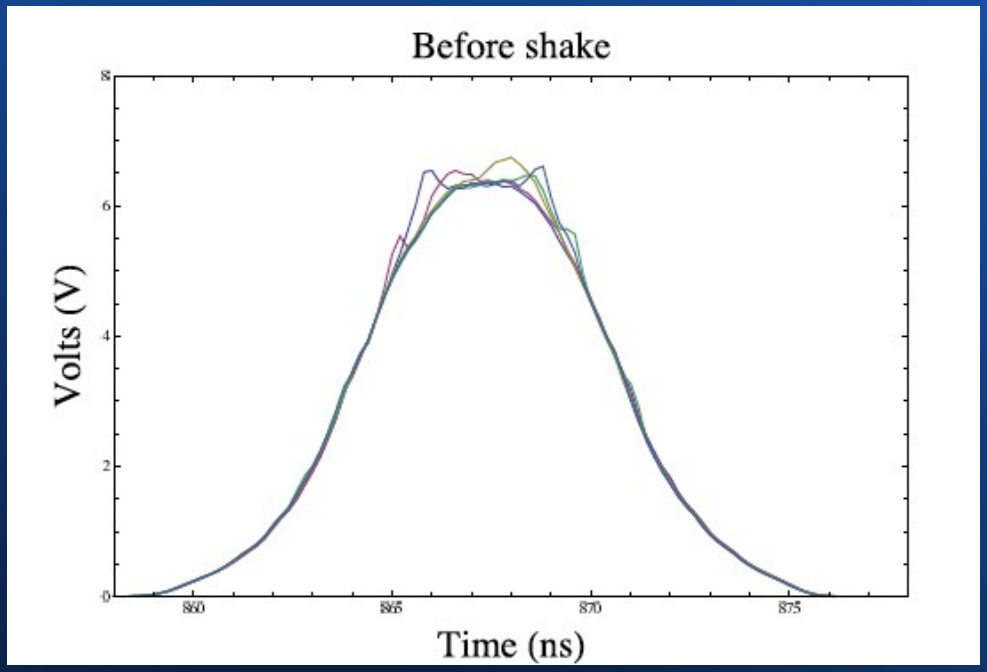
For coalesced bunch, the tip of the bunch dances.

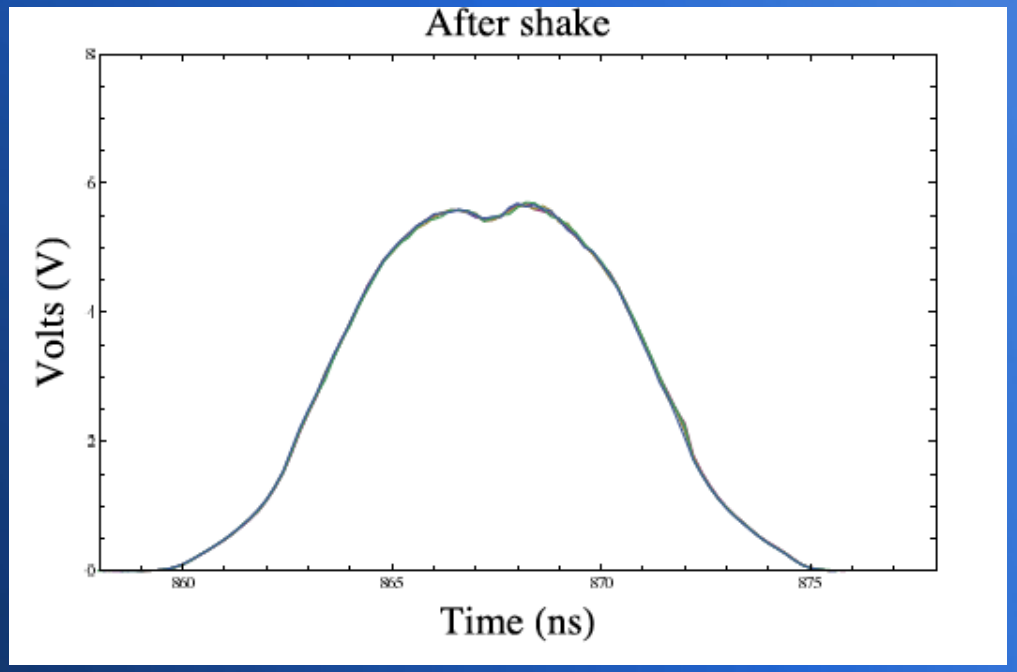
Frames are about 1s apart.

The Experiment

- Inject 2 bunches of coalesced beam
  - Shake beam using phase modulation
  - Use SBD to capture the longitudinal profile of the bunch.
  - Monitor beam loss, centroid motion etc.

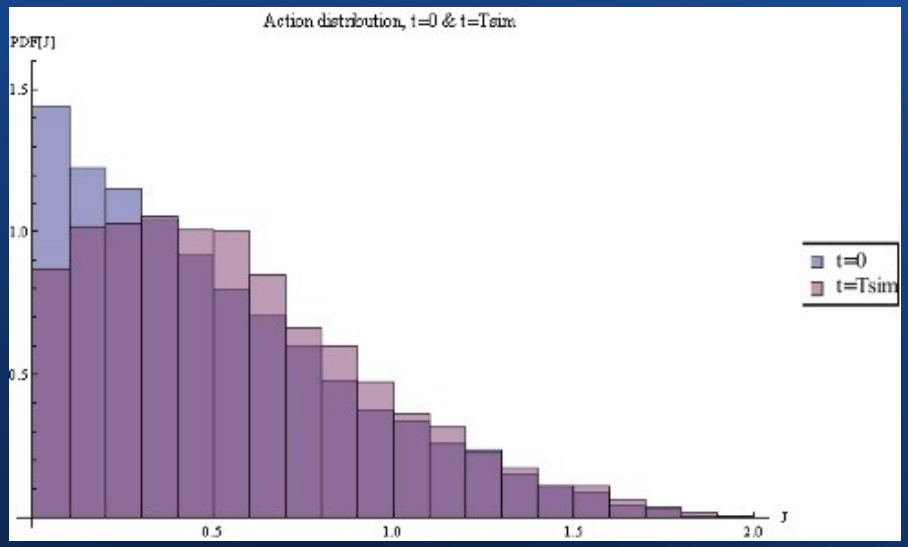
Shaking at 150 GeV

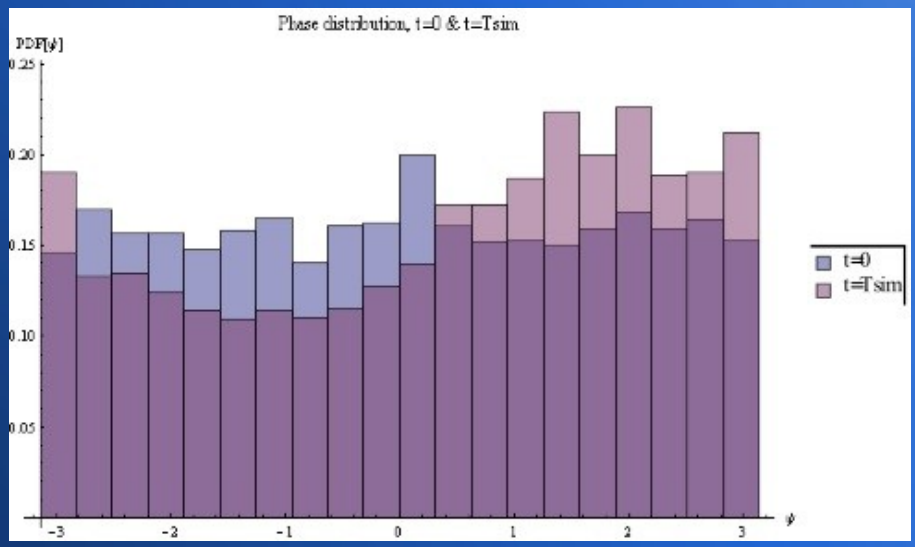


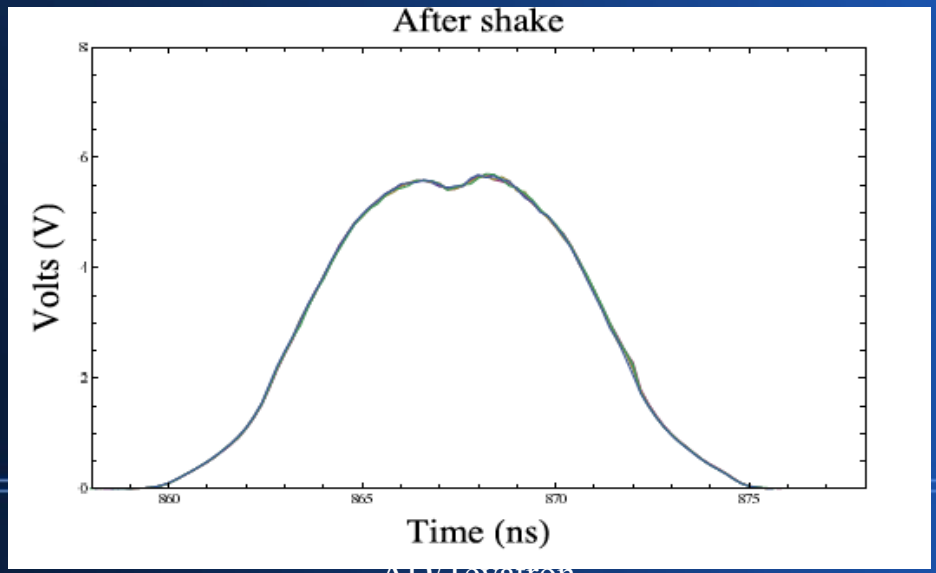


Shake is for ~14 s
Amplitude is 3 deg peak, modulation frequency = 87.47 Hz.
Divot structure forms which was predicted in theory.

Results from Simulations







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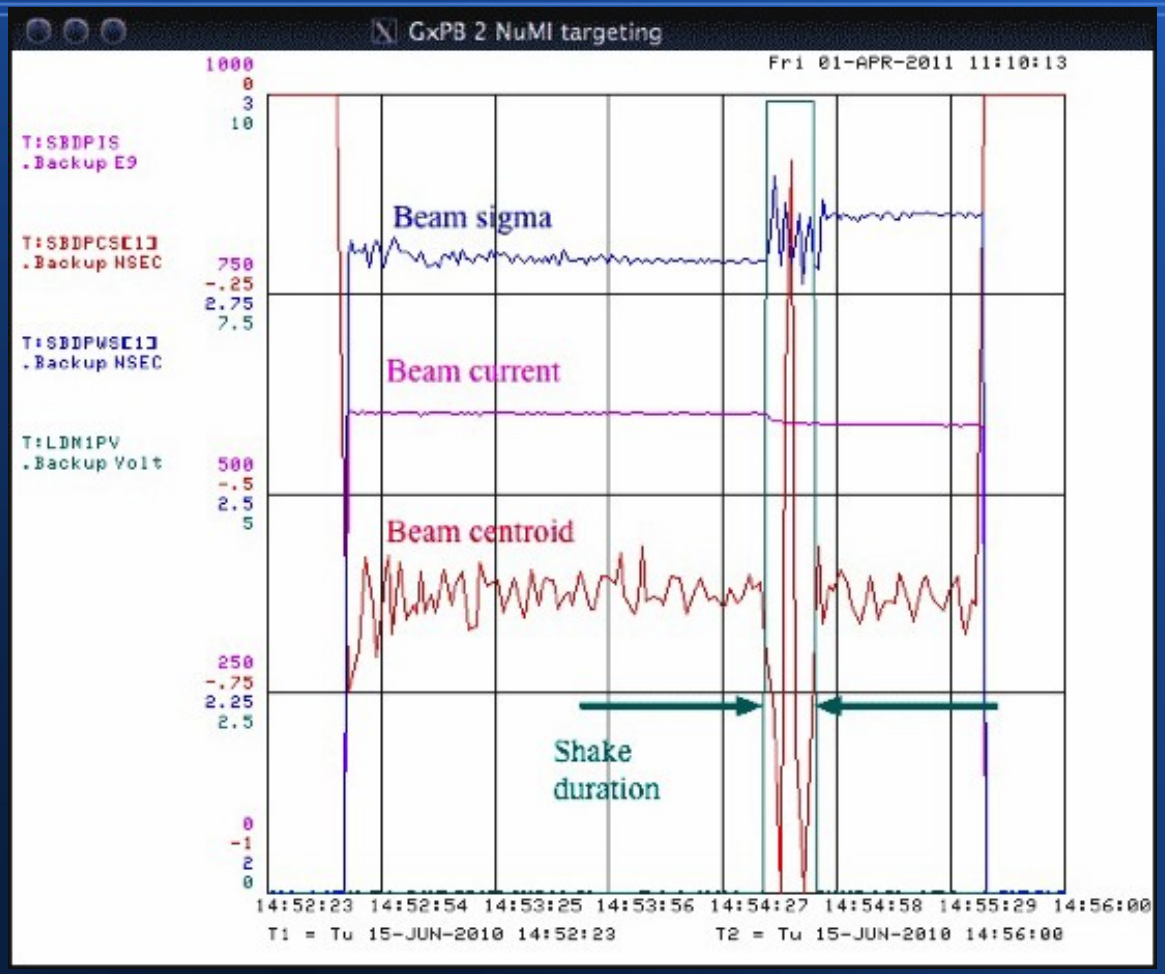
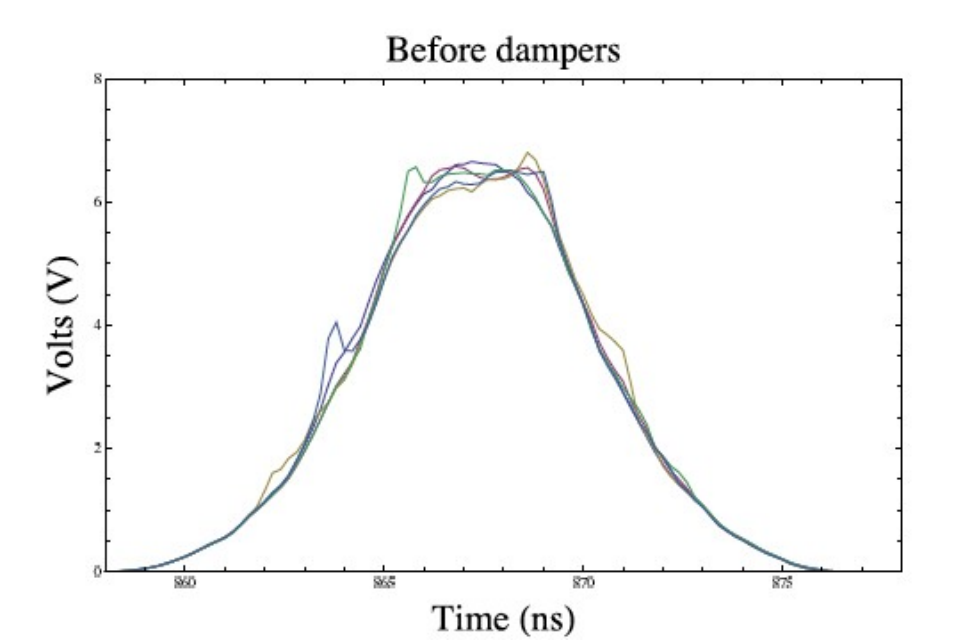
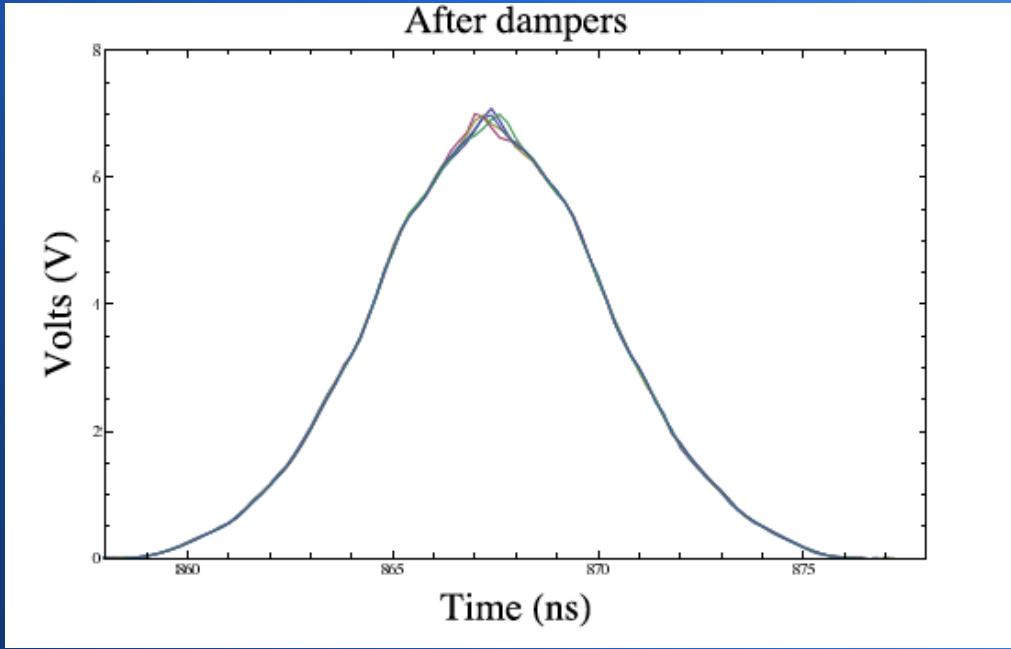
Shaking at 150 GeV (cont'd)



- The beam sigma grows during the shake. (Note shape change!)
- Beam current drops. (Beam fills the bucket)
- Beam centroid still shows some motion although we don't see it by eye. Instrumentation?

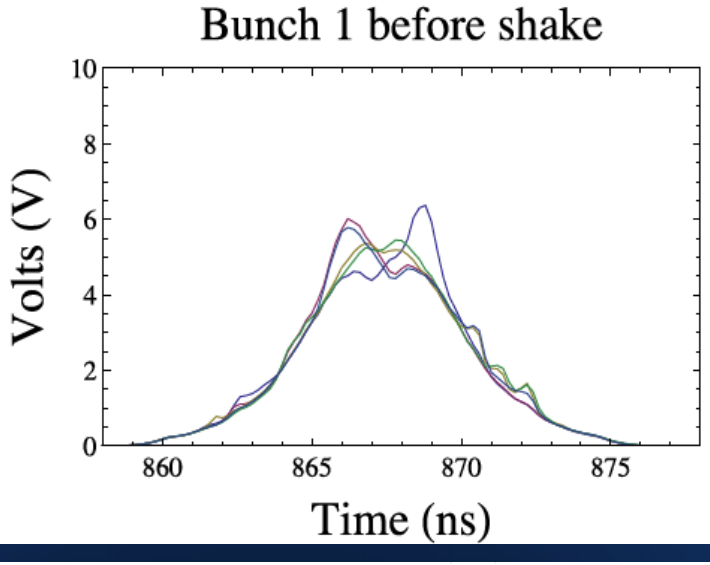
Contrast to Dampers

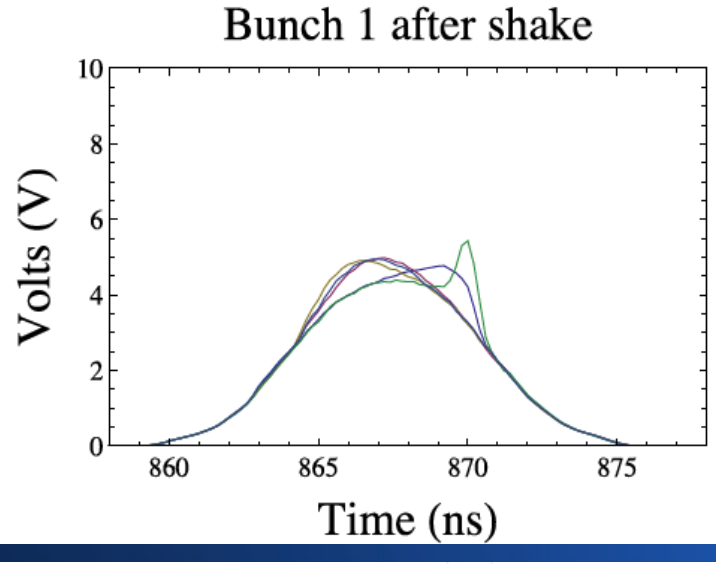


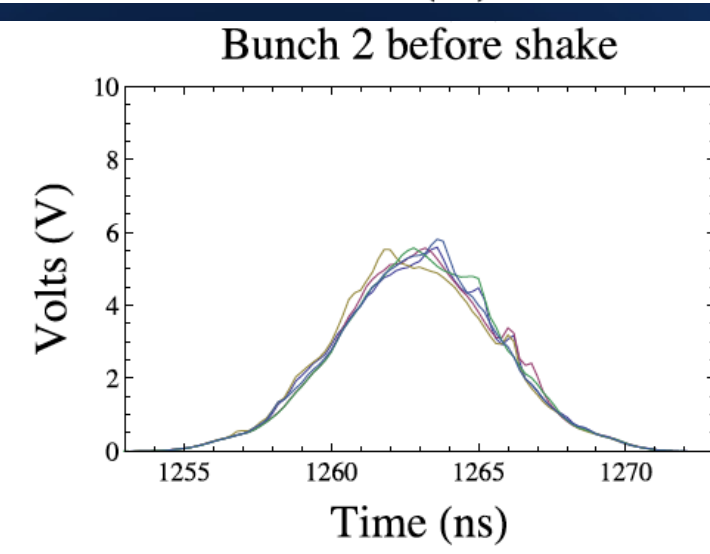


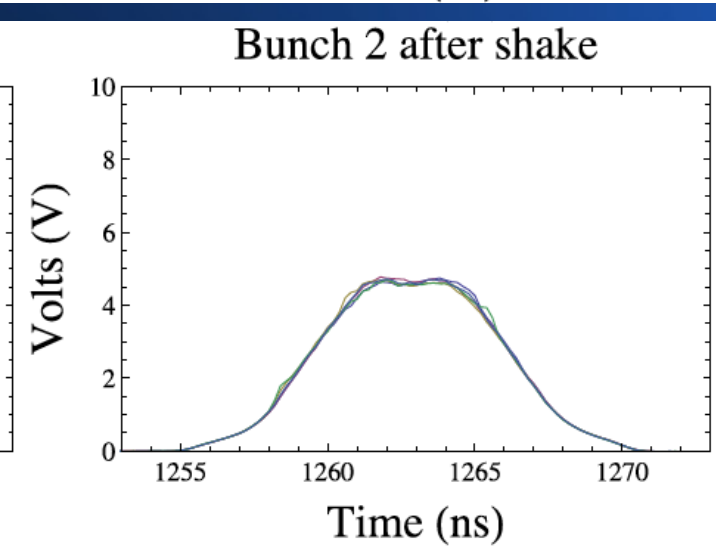
- Dampers damp out the dance.
- The longitudinal distribution takes up more of a triangular shape rather than a more rotund shape from shaking.
- There is no beam loss using the dampers.

Initial Bunch Shape Effects





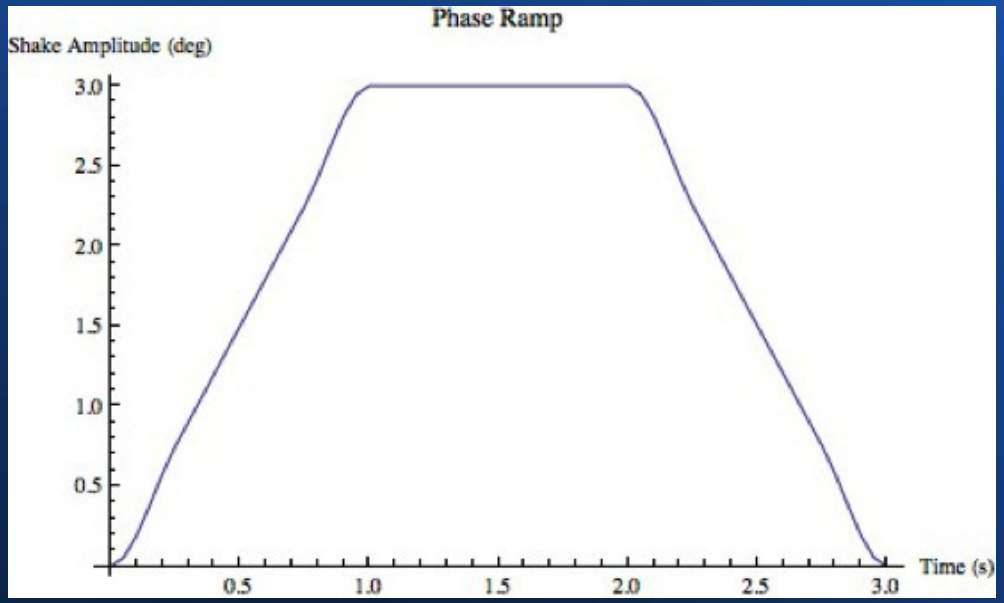




2 bunches shaken at the same time.

Bunch 2 stops dancing after 7-8 s of shaking.
Bunch 1 does not stop dancing.

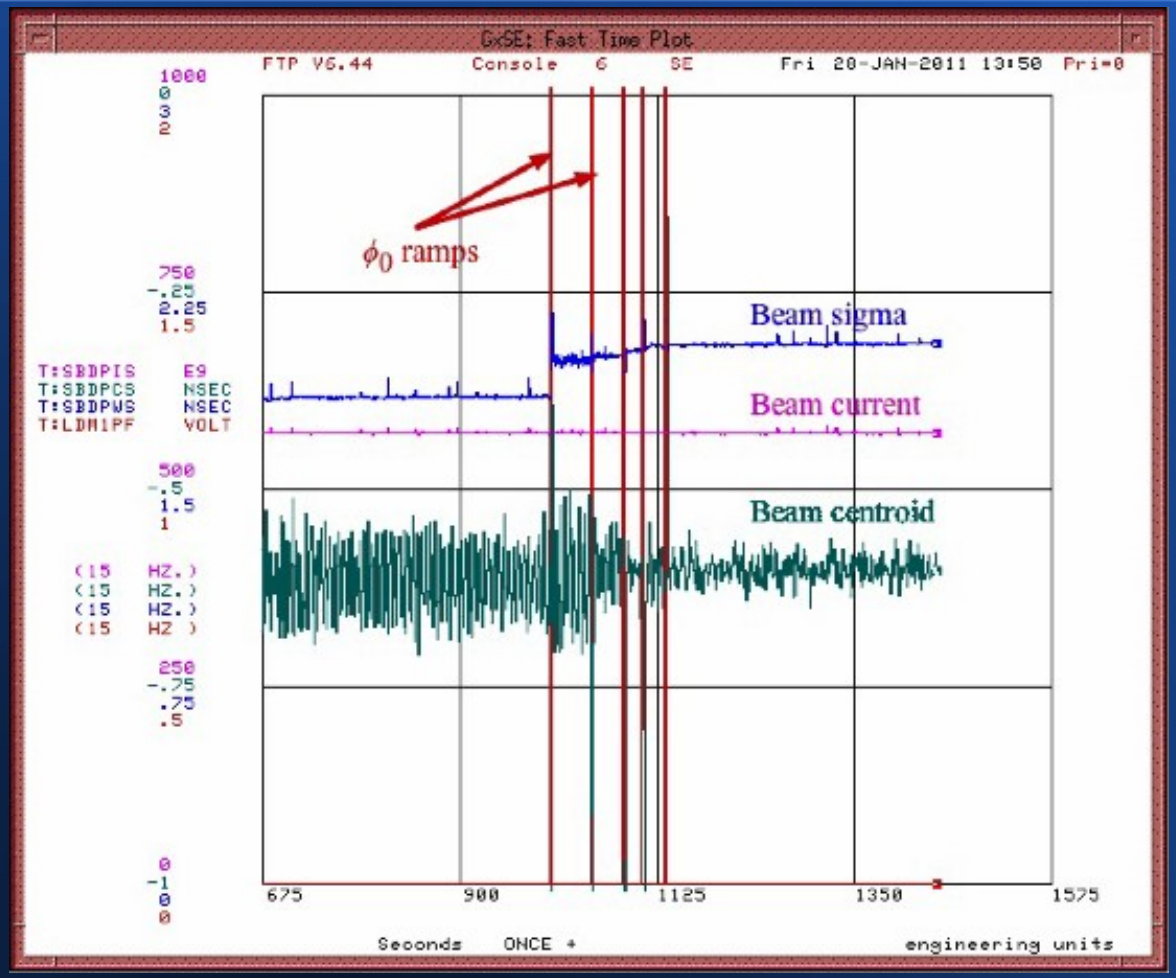
Shaking at 980 GeV



Use a slow ramp to adiabatically start and stop the shake be-cause from observations sudden turn ons cause beam to fall out of bucket – surprising since bucket is 2x larger than beam.

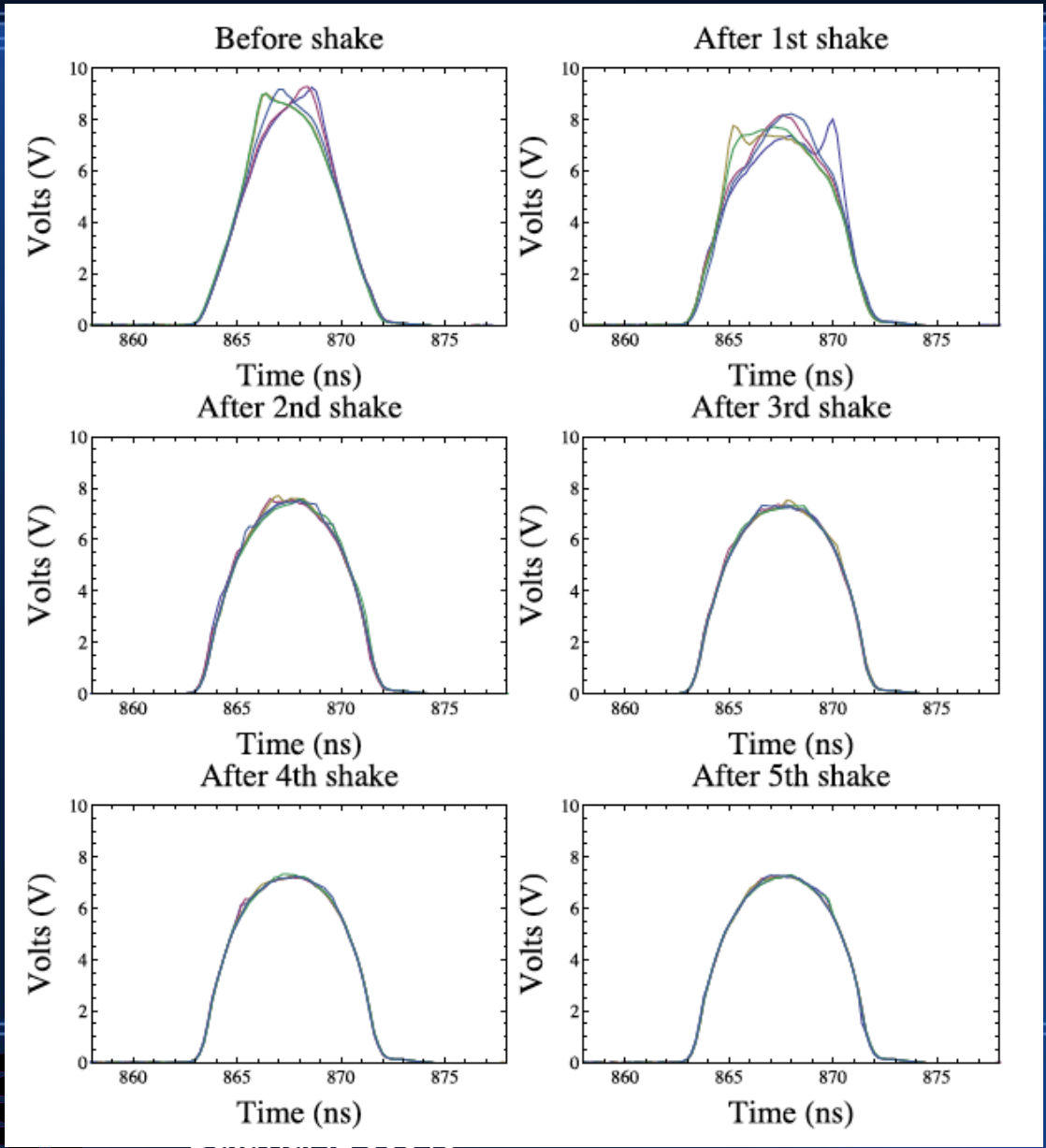
Synchrotron frequency is 34 Hz.

Shaking at 980GeV



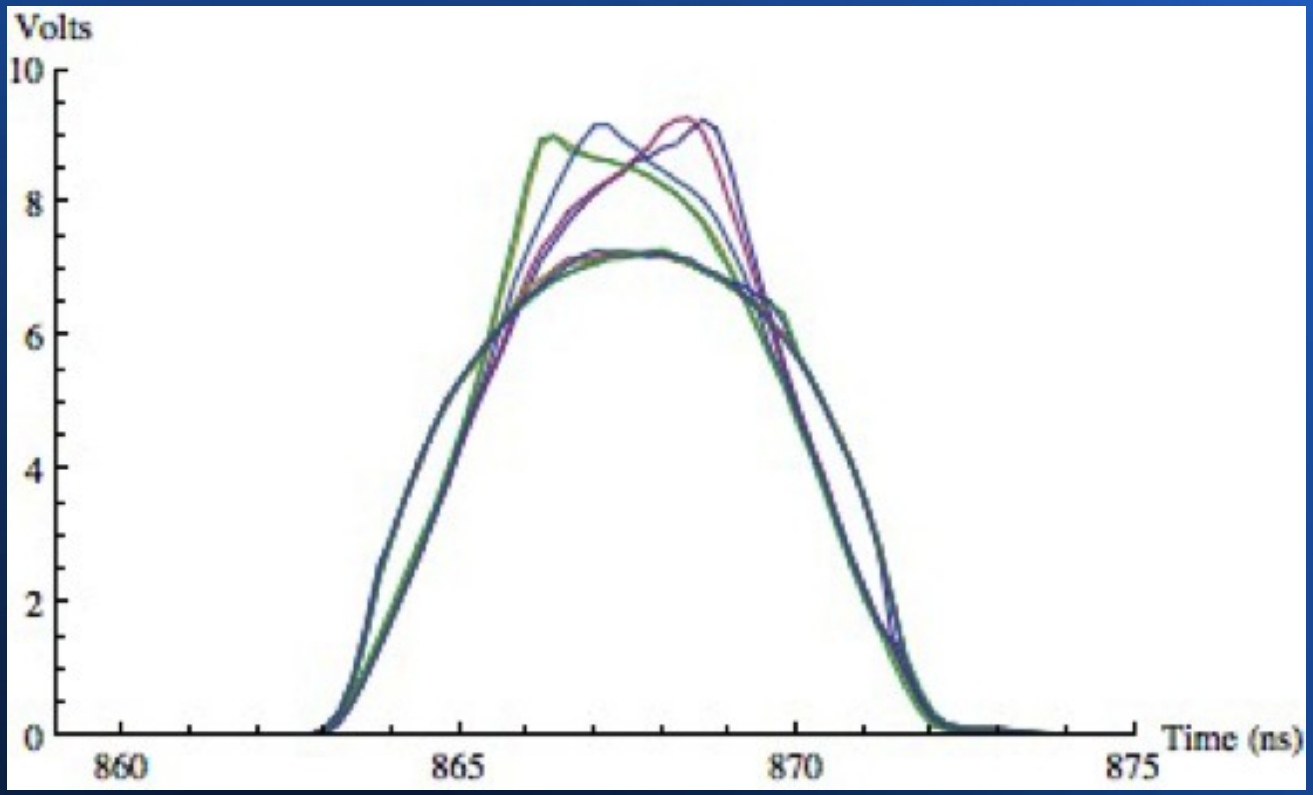
- Beam is shaken 5 times using the ramp.
- There is NO bunched beam loss.
- There is a jump in beam sigma after first shake.
- The beam centroid clearly becomes quieter after shakes.

Shaking at 980GeV



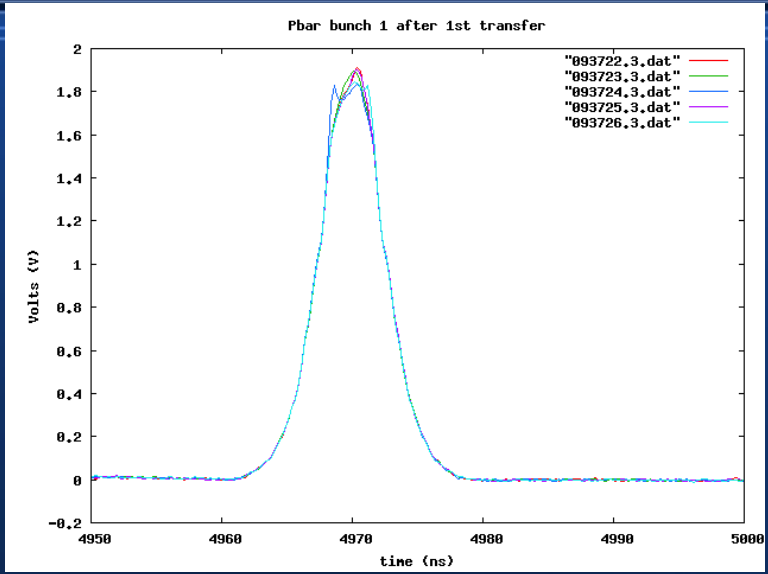
Dancing stops after the 4th shake.
Shape is definitely rounder than before shake.

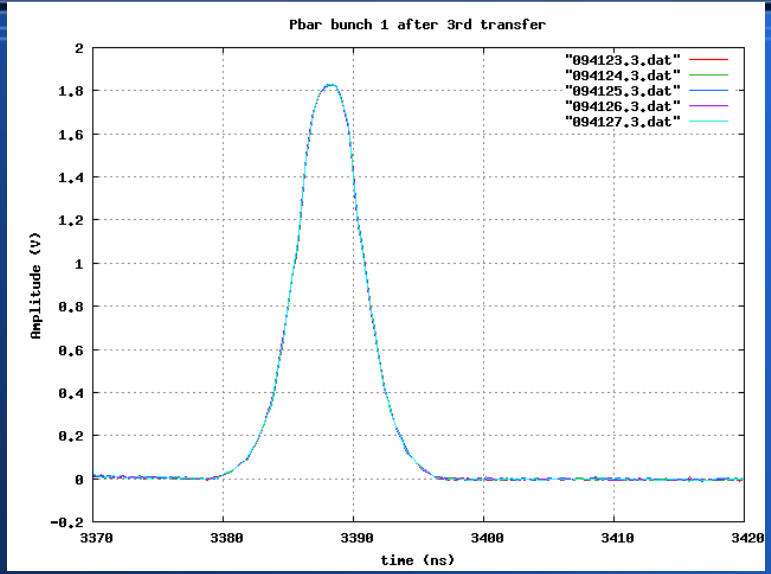
Comparing Before and After Shake

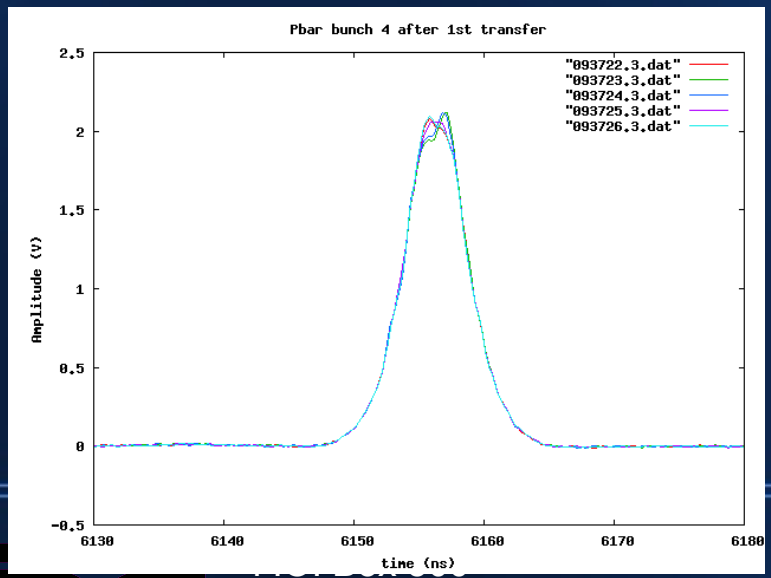


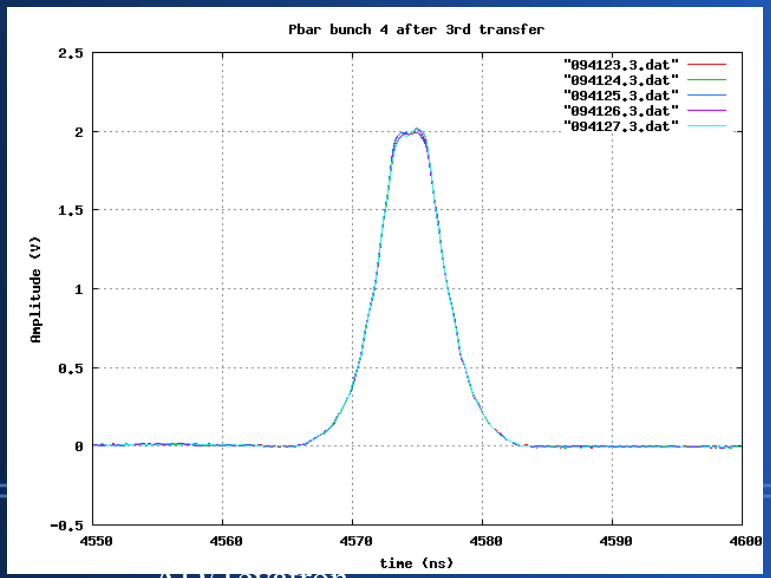
No beam is lost.
There is a redistribution of particles in the bunch.
The distribution looks more rounded.

Side Effect of Proton Damping on Pbars (150 GeV)









Side effect of lon-gitudinal damping of protons.

Pbars are shaken which stops the dancing tips. Divot forms.

Conclusion

- Shaking does indeed stop the bunches from dancing.
- Distribution becomes more rotund than at the start.
- Initial beam distribution may determine the duration of the shake for stopping the dance.
- Sometimes a divot does form which has been predicted by computer simulations.
- This may be a method for stabilizing the beam without using any active damper system.